Selection of Sites for Electronic Warfare Facilities on the Basis of Digital Cartographic Information

Lt. Col. A. BUKERRUM
Col. Yu.Ye. DONSKOV (Res.),
Doctor of Military Sciences
Col. V.A. PAVLOV (Res.),
Candidate of Technical Sciences

Abstract. The authors offer an algorithm for transforming digital cartographic information to input data for making operational-tactical calculations to forecast the capabilities of radio intelligence and radio suppression, and identify tasks that can be automated and solved by using digital cartographic data.

Keywords: electronic warfare, radio intelligence, radio suppression, digital cartographic data, operational-tactical calculations.

Modern-day local wars and military conflicts provide convincing evidence of the growing role of electronic warfare (EW) in military operations (combat actions). As a result, the list of tasks handled by commanders of EW units of all kinds, the commands and staffs of groups of forces (formations) to plan and actually conduct electronic suppression (ES)[1] lengthens and their complexity increases, and, accordingly, the analytical workloads on officers responsible for EW have soared. Moreover, the never-ending need for cuts in time to get the troops (forces) ready for combat that is typical of extremely fluid engagements puts significantly greater demands on the adequacy of assessment of *tactical (tactical-operational)* and *electronic environment (EE)* by commanders involved in order to make reasonable and thoroughly weighed decisions.

Selection of sites for radio direction finding and radio interference stations is one of the basic tasks that have to be fulfilled at the planning stage for EW forces and means to be committed and affect significantly the efficiency of the radio suppression complex (RSC). The relevance of this task grows in a fluid situation when the frequency of site change during a day of fighting grows considerably.

For such stations to be sited with the greatest effect, it is essential to assess, as quickly and as accurately as possible, the *electromagnetic accessibility* of radio intelligence to intelligence sources and *energy accessibility* of radio suppression means to radio interference targets within reach of the radio suppression complex.[2]

Calculations of electromagnetic accessibility areas are based on the traditional technique of measuring electromagnetic intensity parameters at locations of intelligence and direction finding equipment. The underlying element of such calculations is evaluating the size of an electromagnetic accessibility area that depends on several factors such as power of the emitted signal, sensitivity of the radio direction finder receiver, and parameters of the radio wave propagation (RWP) medium. Since the power of the emitted signal and sensitivity of the radio direction finder are conditionally constant magnitudes, the selection of positions for intelligence and direction finding equipment depends mostly on the assessment of radio wave propagation conditions along radio intelligence paths.

When radio waves propagate over the surface, the semiconductive ground layer and obstacles commensurable with the wavelength are known to absorb and reflect radio waves. In turn, they occasionally reverse wave polarization. The quantified magnitudes of these effects depend on the electrical parameters of the ground surface such as typically permittivity and conductivity attributable to the properties of ground surface structure (moisture, bedding, topsoil, vegetation, terrain relief, density of urban development, if any, and so on) in the path of radio wave propagation.

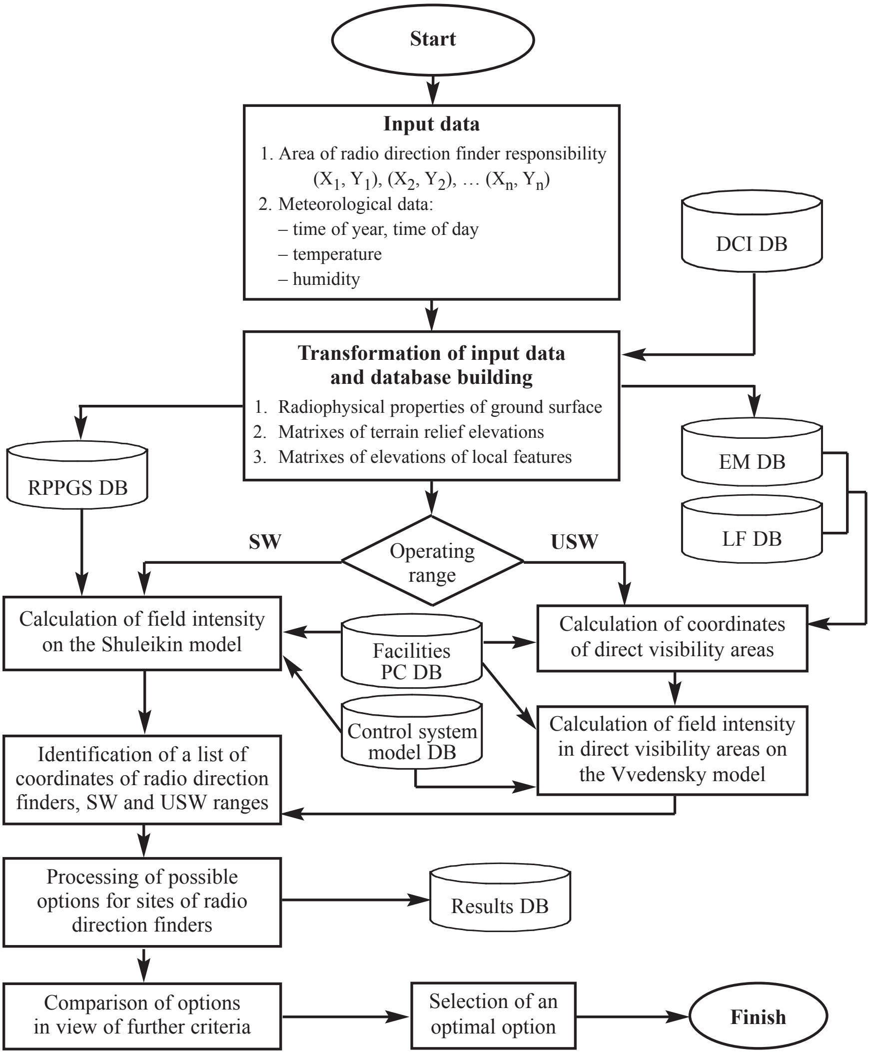
Estimate of the electromagnetic accessibility area of a particular radio wave source (RWS) has to consider the combined effect of all the factors listed above on the radio wave propagation path. This can be done at a considerable cost in time needed to process a large amount of information and ultimately calls for the need to use new information technologies.

Whatever calculations are made today for this purpose tend to draw extensively on ***digital (electronic) topographic maps*** that show all terrain details – relief and local features. These authors have analyzed the possibility of digital cartographic information (DCI) being used to accelerate the selection of preferred areas for siting intelligence and electronic suppression facilities to give the required efficiency to the radio suppression complex and assure its survival at acceptable economic costs, and developed a general algorithm for selecting sites for radio direction finders (Fig. 1).

Digital cartographic information is provided today in the form of *digital terrain maps (DTM)* showing relief data and type of natural and manmade features on the terrain (kinds of vegetation, if any, bodies of water, populated localities, transportation routes, etc.).

Digital terrain map data are divided into *raster, vector, textual, and image* types.

Raster data contain information on the elevation and type of terrain at every point. A raster file of a digital map shows a rectangular area of terrain (map sheet), and all files have an identical size. The program described here does not



DCI DB	Digital cartographic information database
EM DB	Elevation matrix database
LF DB	Local features database
RPPGS DB	Database of radiophysical properties of ground surface
PC DB	Performance characteristics database
CSM	Control system model

Fig. 1. **General algorithm for selecting areas for siting radio direction finders**

place any limitations on digital map resolution, and the higher the resolution, the more accurate are the parameters computed and the larger the size of map files. Radio lines are generally computed on maps having a point (pixel) size equal to a rectangular area of terrain measuring 30 × 30 m, 50 × 50 m, and 100 × 100 m.

Vector data describe linear features that need to be shown on the map. Coordinates of the points of various types of vector features, for example, roads and rivers, are to be saved in different files that are unlimited in number.

Textual data are names of geographical features (cities, townships, and so on).

Images are, as a rule, scanned paper topographic maps or air photographs. They are used to supplement raster and vector data.

The structure of digital terrain map features is given in Fig. 2.

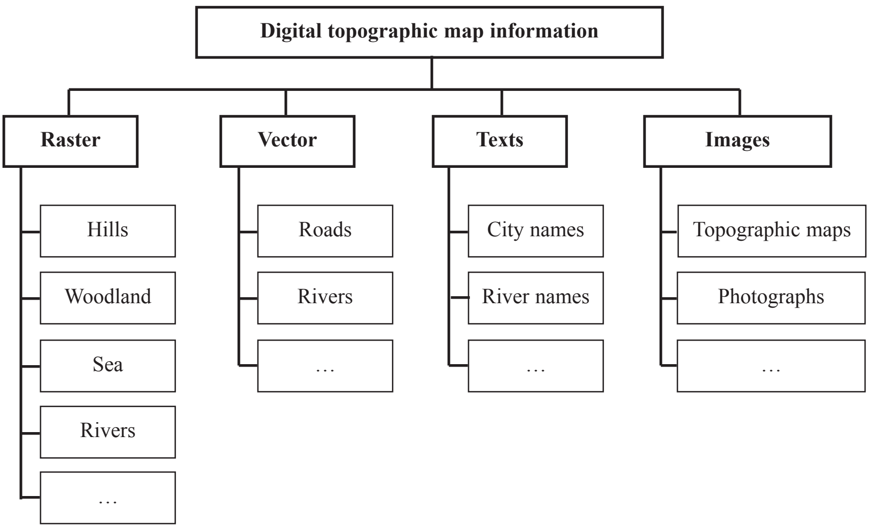


Fig. 2. **Structure of the digital terrain map content**

The ***following information is needed*** for the algorithm described here to be used for selecting areas for siting radio direction finders in practice: boundaries of the area of the radio suppression complex's responsibility, details of the terrain relief, performance characteristics (PC) and coordinates of radio intelligence facilities and sources (radio suppression and radio interference targets), performance characteristics of radio intelligence equipment, and weather data for the planned or current time period.

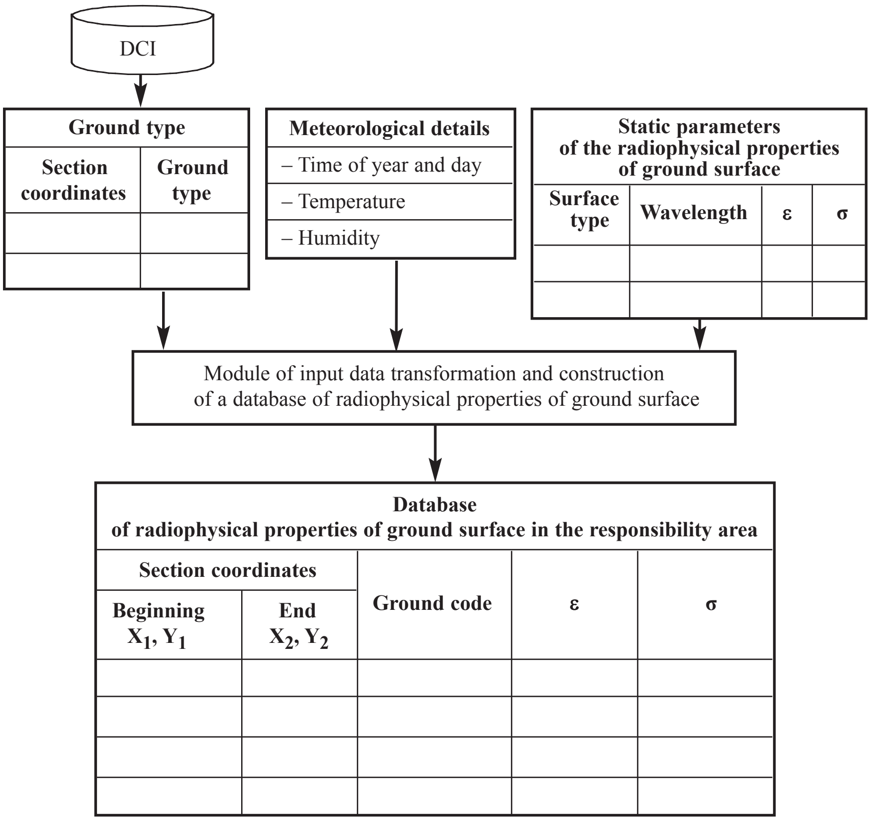
Terrain relief in the area of EW units' responsibility is an important consideration for calculating radio communication paths in various conditions. Simple techniques are used most frequently to assess the influence of prevailing conditions. As a general rule, these techniques are based on averaged characteristics of radio communication, radio intelligence, and electronic suppression paths in the entire area of responsibility. They are inadequate, though, largely because they give no consideration to the specifics of every individual radio wave propagation path.

This inadequacy can be offset by terrain relief data retrieved from the digital cartographic information database and the high speed of modern personal computers that help solve complex problems by making calculations through examining the parameters of real areas making up radio communication, radio intelligence, and radio suppression paths. For the radio wave propagation conditions in a selected area to be described adequately by these authors' algorithm, the computerized automated system is to have an electronic map of the terrain in a standard format (Arc Info, Integration UT, Map Info, or Panorama, and so on).[3] The map serves as a basis for selecting sites for radio intelligence facilities and noise generating stations, and for making the bulk of calculations that give consideration to the terrain relief. This technique helps cut significantly the time needed to calculate the required parameters of satisfactory quality and, therefore, increase significantly the speed of problem solution in general.

To make a point, digital terrain map details cannot be used in calculations directly because the map does not contain details of the parameters (magnetic permeability and electrical conductivity of the underlying surface) of the radio wave propagation path. These details of the ground in various sections of the radio intelligence path can be obtained from reference materials, with consideration for the weather. A model for transforming information from various sources to build a database needed to select sites for radio intelligence and radio noise facilities is illustrated in general form in Fig. 3.

The algorithm shown above helps make a rational selection of sites for radio intelligence and radio direction finding facilities to give required accuracy in identifying the location of radio intelligence sources. Its allows the following steps to be taken sequentially: calculating and constructing a terrain relief profile between any two points with consideration for the height of the aerials of intelligence sources and facilities, and obtaining the value of the relative gap of a direct beam at any point of the radio intelligence path; calculating the radio path profiles within the USW range, establishing the radio path profiles within the USW range, and constructing zones of direct visibility from the adversary's radio communication stations within that range; calculating the attenuation multiplier and level of a signal received within the shortwave (on the Shuleikin model) and ultrashort wave (on the Vvedensky model) ranges within the given area on radio intelligence paths; calculating the signal-to-noise ratio in the given site of radio direction finders; determining the expected probability of error in determining the location of radiating facilities in the given area; and building maintenance areas for the radio suppression complex subsystems.

To conclude, digital terrain maps reduce the time required to perform all steps by 20% to 25% and increase the speed of making a selection of sites for positioning EW forces and facilities by 30% to 50% and simultaneously make the calculations more authentic.



ε – electrical conductivity

σ – magnetic permeability

Fig. 3. **Input data transformation and construction of a database of the radiophysical properties of ground surface**

NOTES:

1. *Voyennoye iskusstvo v lokal'nykh voynakh i vooruzhyonnykh konfliktakh* [Military Art in Local Wars and Military Conflicts], Voyenizdat Publishers, Moscow, 2009, p. 764.
2. A.I. Kupriyanov, A.V. Sakharov, *Teoreticheskiye osnovy REB. Uchebnoye posobiye* [Theoretical Basics of Electronic Warfare. Textbook], Vuzovskaya kniga Publishers, Moscow, 2007, p. 356.
3. I.G. Zhurkin, S.V. Sheitura, *Geoinformatsionnyye sistemy* [Geoinformation Systems], KULITS-PRESS, Moscow, 2009, p. 272.